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ABSTRACT

An empirical study was conducted using Navy trainees to evaluate the effectiveness of instructional modules designed to train Interior Communications electricians in the maintenance and repair of alarm and warning systems installed in ships to signal unsafe conditions. These modules, each containing six lessons, were developed to augment or replace current instruction on such systems. Six classes of Interior Communications "A" School trainees were trained in supervised alarm and warning systems using the individualized instruction materials. These students and a comparison group of "C" School students were pretested and posttested using comprehensive tests, the difference in scores being the primary measure for evaluation. Results indicate that the instructional materials perform adequately in the training environment, leading "A" School students to perform as well on the posttest as the more experienced "C" School students. A student attitude survey revealed overall neutrality toward the materials. Based on these results, it is recommended that the validated supervised alarm systems materials be considered for inclusion in the individualized Interior Communications curriculum. (CWM)

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INTERIOR COMMUNICATIONS SUPERVISED ALARM AND WARNING SYSTEMS: VALIDATION OF INSTRUCTIONAL MATERIALS

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Experimental instructional development procedures were used to develop Interior Communications School Instructional Modules on Alarm and Warning Systems. On an empirical test of the material students showed significant gains on a posttest and performed as well as more advanced students on the same test items.

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FOREWORD

This research and development was performed in response to Navy Decision Coordinating Paper, Education and Training Development (NDCP-Z0108-PN) under subproject Z0108-PN.30A, Adaptive Experimental Approach to Instructional Design, and under the sponsorship of the Director of Naval Education and Training (OP-99). The overall objective of the subproject is to develop an empirically-based instructional design support system to aid developers in deciding on instructional alternatives based on costs/benefits and specific resource limitations. The immediate effort is concerned with the validation of instructional materials for Interior Communications (IC) Alarm and Warning Systems. A previous report, NPRDC Special Report 79-8, covered the development of the training materials. The effort was part of a test-bed research program approved by the Experimental Training Programs Policy Board, established by a Memorandum of Agreement between the Chief of Naval Education and Training and the Navy Personnel Research and Development Center. Dr. William E. Montague was Project Director for this effort.

Appreciation is expressed to the staff of the Interior Communications School, San Diego, California for their assistance and cooperation.

Results of this research and development are intended for use by the Chief of Naval Education and Training Support (specifically, the Instructional Program Development Centers), the Chief of Naval Education and Training, and the Chief of Naval Technical Training.

DONALD F. PARKER
Commanding Officer

SUMMARY

Problem

Observed deficiencies in the repair and maintenance of shipboard alarm and warning systems have led to requests for increased instruction on these systems. Using experimental procedures, NAVPERSRANDCEN scientists and the Interior Communications (IC) Curriculum Development Group at the IC School, Service School Command, Naval Training Center, San Diego, developed instructional modules for four IC alarm systems. Before these modules can be implemented, they must be validated empirically.

Purpose

The purpose of this effort was to validate previously developed instructional modules for IC alarm and warning systems.

Approach

IC School students (N = 111) were administered the modules, and pre- and posttest scores were compared. Posttest scores were also compared with scores of advanced "C" School students on the same test items.

Results

"A" School students performed significantly better on the posttest than on the pretest, t (110) = 14.36, $p < .01$. They also performed as well as "C" School students.

Conclusions

The instructional materials appear to perform adequately in operational training, and lead to "A" School student test performance comparable to that of much more experienced "C" School students. The inclusion of the hands-on exercises would lead to even better preparation of "A" School students for their operational assignments.

Recommendations

The first six lessons of the supervised alarm and warning systems instructional materials should be added to the existing IC "A" School curriculum. This would require about 4 to 8 additional course hours, depending upon the amount of hands-on training included. The additional modules may be included as time permits, or a short additional module describing essential differences among, and application of, other alarm and warning systems could be written.

These materials should be considered for inclusion in any new IC curriculum.

CONTENTS

	Page
INTRODUCTION	1
Problem	1
Purpose	1
Alarm and Warning Systems	1
Background	1
METHOD	3
Subjects	3
Materials	3
Design	3
Procedure	3
RESULTS AND DISCUSSION	5
Lessons Completed and Instructional Time	5
Lesson Effectiveness	5
Comparisons on Individual "C" School Items	5
Attitude	6
CONCLUSIONS	9
RECOMMENDATIONS	9
REFERENCE NOTES	11
APPENDIX--SUPERVISED ALARM SYSTEMS: FINAL TEST	A-0
DISTRIBUTION LIST	

INTRODUCTION

Problem

Observed deficiencies in the repair and maintenance of shipboard alarm and warning systems have led to requests for increased instruction on these systems. Using experimental procedures, NAVPERSRANDCEN scientists and the Interior Communications (IC) Curriculum Development Group at the IC School, Service School Command, Naval Training Center, San Diego, developed instructional modules for four IC alarm systems. Before these modules can be implemented, they must be validated empirically.

Purpose

The purpose of this effort was to validate previously developed instructional modules for IC alarm and warning systems.

Alarm and Warning Systems

Alarm and warning systems are installed in ships to signal unsafe conditions such as low or high temperatures, pressures, or fluid levels. Such systems are called "supervised" when they can signal faults in their own circuits. These systems are typically energized but unmanned, with audible alarms to warn watchstanders of both alarms and circuit faults. IC electricians are responsible for the maintenance and repair of these systems.

Supervised alarm and warning systems typically consist of a control switchboard, one or more audible alarms, and one or more sensors. Three types of electromagnetic control switchboards are now in use, with a solid-state switchboard being introduced. (The latter was not included in this development project because it is not yet in common use and it requires little maintenance or repair.) Of the three most common switchboards, the N-3 is the most complex; the B-51 and B-52 are simplified versions of the N-3. All three contain the same basic alarm and fault-sensing circuits. All sensors contain a normally open single-pole switch and a resistor wired in parallel with the switch contacts.

Background

In a Memorandum of Understanding (CNET, 1975) between the Chief of Naval Education and Training and NAVPERSRANDCEN, the IC "A" School was chosen as the test bed for developing and evaluating innovations in training technology. One of the efforts undertaken under this agreement was the development of instructional materials to augment or replace the current instruction on alarm and warning systems.

The rationale for developing the alarm and warning systems materials first, and a full account of the developing process, is available in Interior Communications Supervised Alarm Systems: Development of Instructional Materials (NPRDC Special Report 79-8). A brief summary of those developmental efforts is presented here for convenience.

In March 1976, NAVPERSRANDCEN instructional psychologists began assisting the IC Curriculum Development Group in the development of an individualized "A" School curriculum. Front-end task analyses had already been performed, and the learning and enabling objectives had been specified and approved by the Chief of Naval Technical Training.

In August 1976, responsibility for IC curriculum development was transferred to the Instructional Program Development Center, Naval Education and Training Support Center, Pacific, and the IC Curriculum Development Group was disbanded. At that time, 17 instructional modules on IC alarm and warning systems were in various stages of completion and individual try-out. Since these modules overlapped considerably, the NAVPERSRANDCEN scientists decided to complete the modules for four representative systems:

1. The Desuperheater High Temperature Alarm System, which uses the M-3 alarm switchboard. Operation, circuitry, troubleshooting, and repair are treated in detail.

2. The Feed Pressure Alarm System, which also uses the M-3 switchboard. Operation, circuitry, troubleshooting, and repair are treated as review material.

3. The Deaerating Feed Tank Water Level Alarm System, which uses the B-52 switchboard, and the Dial Light Indicator remote display. Operation, circuitry, and troubleshooting are similar to the M-3; emphasis is on aspects peculiar to the B-52.

4. The Lube Oil Low Pressure Alarm System, which uses the B-51 switchboard. The material is largely review, but introduces the cross-connection, or slaving, of one alarm system with another switchboard.

Each instructional module contained six lessons. Lesson 1 presented the function of the system and the function of the major electronic and magnetic components, and in the process identified the larger functional units and their components. Lesson 2 covered the display patterns associated with the various operational conditions and tests. Lesson 3 explained the use of the Maintenance Requirement Cards (MRCs) in the Planned Maintenance System (PMS). Lesson 4 identified the circuits of the alarm system and explained how they worked and affected other circuits. Lesson 5 presented descriptions of system malfunctions and documented the troubleshooting strategies used to isolate and identify their causes. (A different malfunction was used with each alarm system.) Lesson 6 covered the repair tasks required to correct the malfunctions identified in Lesson 5. Lessons 5 and 6 were supported by laboratory experience with pre-faulted systems, and all lessons were extensively illustrated.

Subjects

Six classes of IC "A" School trainees (N = 111) were trained in supervised alarm and warning systems using the individualized instructional materials developed by [redacted] scientists and the IC Curriculum Development Group. Over 90 percent of the trainees were 20- or 19-year old males who had completed recruit training and 25 modules of basic electricity and electronics before entering the "A" School. Less than 10 percent had any operational Navy experience.

A comparison group consisted of six classes (N = 47) of students from the Propulsion Plant Alarm and Indicating System (1200 PSI) "C" School course. About 80 percent of these students were petty officer Fleet returnees and all but three were "A" School graduates.

Materials

The instructional modules were printed and bound in separate booklets and were issued to trainees one module at a time. (Copies of these modules are available upon request from [redacted].)

Two parallel versions of a 30-item comprehensive test were constructed of items written to correspond to objectives. Eleven of the items were taken from an existing "C" School test (see appendix). Trainees also had a time sheet to be filled out as they progressed, and had answer sheets for practice questions. Finally, an attitude survey comparing the instructional modules with other individualized training materials was administered at the end of the instructional period.

Design

All "A" School trainees were pretested on one form of the comprehensive test and posttested on a second version.[1] The primary measure for the evaluation was the difference between pre- and posttest scores. Performance on a subset of the comprehensive test questions, taken from the 1200 PSI "C" School's first-week comprehensive test, was compared with the performance of "C" School trainees on the same items.

Procedure

Trainees studied the supervised alarm systems materials after completing the self-paced, computer-managed final unit of IC "A" School. Usually the first trainees began their study on Tuesday afternoon, with the bulk of the class arriving by noon Wednesday. When the trainees arrived, the experimenter informed them of the following:

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[1]Each class of trainees was assigned to one of three instructional conditions. Condition I trainees answered inserted questions and took a test after each lesson. Condition II trainees received only the lesson tests, and Condition III trainees answered only the inserted questions. A comparison of the gain scores revealed no significant difference between groups, so the groups were combined for analysis.

> The supervised alarm materials you will be studying are included to replace the alarm portion of the Circuits One book, which was omitted from your instruction. The material is more detailed than that in Circuits One and is similar to what is taught in the first week of the 1200 PSI "C" School. The materials were developed by the EC School Curriculum Development Group and NPTSC as part of the program to individualize all of the school. The material on supervised alarms was developed first because the Propulsion Examination Board, which rates the readiness of propulsion systems, found many ships with alarm systems that were either inoperative or disconnected. The fleets have requested that the school provide more training in maintaining and troubleshooting supervised alarm systems. Because supervised alarm systems are quite simple systems and use types of components you have had experience with in NUCP and "A" School, we are going to give you a pretest to find out how much you already know or can figure out. If your final test score is higher than your pretest score, it will show that studying the material helped you learn.

After the pretest had been administered and scored, the trainees were given a background module, "Basic Steam Cycle," and the first training module, "Superheater High Temperature Alarm System." Answer sheets and instructions on how to check answers were provided, as were the criteria for advancement to other modules. Trainees were instructed to record their actual study times for each lesson of each module. Lessons 5 and 6 of each module contain hands-on, troubleshooting, and repair exercises. Trainees did not perform these exercises due to a shortage of pre-faulted equipment.

The trainees studied as much of the materials as they could before 1630 on Thursday. At that time, the instructional materials were collected and the posttest was administered, regardless of the amount of material the trainees had covered. An attitude survey comparing the supervised alarm materials with the individualized instructional materials in NUCP and the last unit of EC "A" School was completed by the trainees as they waited for their tests to be corrected. The trainees were then informed of their pre- scores as well as the percentage correct.

This study was run under less than ideal experimental conditions. First, all subjects had completed the normal EC "A" School program, and knew that their work in the study would not affect their class grade or standing. Further, the trainees viewed the study as an infringement on their free time, so motivation was low. Second, trainees typically had many other responsibilities during the last week of school (e.g., record updating, medical and dental appointments). Therefore, trainees frequently had to interrupt their study. Finally, the study was conducted a civilian experimenter rather than by Navy personnel, a fact that may have led the trainees to minimize the study's importance. These conditions resulted in loss of some data, such as time logs and posttest scores.

Lessons Completed and Instructional Time

Subjects completed from 0 to 11 lessons; the average was 5.04 (SD = 5.23). The mean times to completion for lessons 1 through 6 were 35 minutes, 43 minutes, 29 minutes, 63 minutes, 43 minutes, and 28 minutes, respectively. Instructional time for the first six lessons averaged about 230 minutes.

Lesson Effectiveness

Because less than 20 percent of the students had studied any subjects other than the mandatory first module, most comparisons that blend data from the other modules were dropped for the statistical analysis. Of the 19 remaining items, 11 were taken from the "C" School Book 1 Comprehension Test. All statistics and comparisons are based upon this abbreviated version of the comprehension test.

Two t tests were performed on the differences between pretest and posttest scores. The mean number of items correct on the pretest was 8.63 (SD) and the mean performance on the posttest was 11.36 (SD), a difference in gain of 2.81 items. A t test of this difference showed a significant gain: t (113) = 10.36, p < .05.

A second comparison was made of the difference in performance on the pretest and posttest for the 11 "C" School items. The mean number correct on the pretest was 3.50 (SD), while the posttest mean was 5.77 (SD). The gain of 2.79 items was significant: t (113) = 8.87, p < .05.

Because subjects completed different numbers of lessons, the gain scores were also analyzed as a function of the number of lessons completed. Accordingly, two analyses of variance were performed. The first analyzed gain scores for all items on the comprehension test for three levels of lessons completed: zero to three, four or five, and six or more. The mean gains for these levels were 1.28, 3.38, and 7.00, respectively. There was a significant effect for lessons completed: F(2,110) = 8.46, p < .05.

A similar analysis, performed on gain scores on "C" School items, was also significant. Mean gains were 1.20 for zero to three lessons completed, 1.83 for four or five lessons, and 3.80 for six or more lessons, F(2,110) = 3.84, p < .05.

Comparison on Individual "C" School Items

Table 1 summarizes by chi-square tests of independence comparing the performance of experimental students and "C" School students on each of the 11 "C" School items. For this analysis, experimental students were grouped according to the number of lessons completed. The performance of experimental students improved, relative to "C" School students, with the number of lessons completed. Students who completed six or more lessons performed better than "C" School students on nine items (.01), on all ten items, and worse on three items (8, 9, and 11). A likely explanation for the poor performance on items 9 and 11

[illegible]

[illegible]

[illegible]

Table 1

Performance of Experimental Trainees and "C" School Trainees on Items from "C" School Week 1 Test

Lessons Studied	N	Statistic	Test Number[a]																			
			3		5		8		9		15		17		20		22		23		24		25	
			r	w	r	w	r	w	r	w	r	w	r	w	r	w	r	w	r	w	r	w	r	w
0-1	32	Percent	97	3	38	62	34	66	25	75	25	75	44	56	56	44	44	56	34	66	13	87	31	69
		χ^2[b]	NS		17.12*		38.72*		22.17*		16.84*		6.38*		6.71*		NS		9.70*		23.30*		5.90*	
2-3	33	Percent	100	0	73	27	33	67	33	67	30	70	58	42	76	24	39	61	76	24	18	82	39	61
		χ^2	NS		NS		39.94*		16.50*		13.62*		NS		NS		NS		NS		18.98*		NS	
4-5	24	Percent	96	4	100	0	13	86	29	71	46	54	67	33	63	37	50	50	63	37	13	27	50	50
		χ^2	NS		NS		54.27*		16.18*		4.52*		NS		NS		NS		NS		18.92*		NS	
6+	22	Percent	95	5	91	9	55	45	55	45	78	27	68	32	77	23	36	64	100	0	36	64	45	55
		χ^2	NS		NS		21.45*		3.96*		NS		NS		NS		NS		5.80*		5.79*		NS	
"C" School	47	Percent	98	2	85	15	100	0	81	19	74	26	74	26	85	15	53	17	72	28	70	30	62	38

[a]See Appendix for item text.

[b]Each cell's chi-square is based on a 2 x 2 comparison with "C" School trainee performance. All values are computed with frequency data rather than the percentiles shown above.

*$p < .05$.

CONCLUSIONS

The instructional materials appear to perform adequately in training environment. They lead to "A" School student test performance comparable to that of much more experienced "C" School students, and it is expected that inclusion of the hands-on exercises would lead to even better preparation of "A" School students.

RECOMMENDATIONS

The first module, Desuperheater High Temperature Alarm Systems, should be added to the current IC "A" School curriculum to provide additional training in alarm and warning systems. Although this would require about 4 to 8 additional hours of training, depending upon the amount of hands-on laboratory work, this time could be provided without extending the total duration of "A" School. Time permitting, the three supporting modules could be included, or an additional short module could be prepared that stressed the basic similarity of all supervised alarm systems and pointed out the sensor and display differences that distinguish one system from another.

The validated supervised alarm systems materials should be considered for inclusion in the individualized IC curriculum being prepared by the San Diego Instructional Program Development Center.

REFERENCE NOTES

CNET MEMORANDUM OF UNDERSTANDING, Subj: An agreement between the Chief of Naval Education and Training and the Navy Personnel Research and Development Center (NPRDC) on the conduct of research and development, 8 April 1975.

Wulfeck, W. H., II, & Van Kekerix, D. L. Interior communications supervised alarm system: Development of instructional materials (NPRDC Special Rep. 79-8). San Diego: Navy Personnel Research and Development Center.

APPENDIX

SUPERVISED ALARM SYSTEMS: FINAL TEST

SUPERVISED ALARM SYSTEMS: FINAL TEST

1. The only person who can authorize a person to work on an energized circuit is:

   a. Leading Petty Officer.
   b. Electrical Officer.
   c. Department Head.
   d. Commanding Officer.

2. The four major units of any supervised alarm system are:

   a. _____
   b. _____
   c. _____
   d. _____

3. If two men are assigned to work on different areas of the same circuit:

   a. The senior man tags out the circuit.
   b. Both men tag out the circuit.
   c. The LPO tags out the circuit.
   d. No one tags out the circuit.

4. Alarm units in the B-52 Alarm Panel control the following audio signaling devices:

   a. Remote horn and local bell.
   b. Remote horn.
   c. Trouble buzzer.
   d. Trouble buzzer and remote horn.

5. On the alarm switchboard, if the trouble buzzer sounds, examination of the alarm switchboard will show one or more:

   a. Red targets.
   b. Yellow targets.
   c. Both a and b.
   d. None of the above.

6. Procedures for adjusting a pressure switch are found in:

   a. IC 3 and 2 rate manual.
   b. System technical manual.
   c. Technical data sheet for that switch.
   d. Maintenance requirement card.
   e. All of the above.

7. The word "supervised" in the term "supervised alarm" means:

   a. The system must always be supervised (monitored).
   b. The system will signal loss of power to the sensing circuit.
   c. The system will signal loss of power to the audible alarm devices.
   d. The system will signal increases in current flow.

8. The line unit test switch in the OFF position

   a. De-energizes the supervisory/alarm circuit.
   b. Bypasses the supervisory resistor.
   c. De-energizes the alarm panel.
   d. Bypasses the audible alarm devices.

9. A B-51 alarm panel consists of _____ two-line alarm units.

   a. 1
   b. 2
   c. 3
   d. 4

10. The function of the test lamp on the N-3 alarm switchboard is to:

   a. Indicate the condition of the alarm circuit.
   b. Indicate the condition of the supervisory circuit.
   c. Indicate that the rectifier is functioning.
   d. Indicate that audible devices are turned off.

11. How is an alarm isolated?

   a. By turning the unit test switch to OFF.
   b. By turning the silent test switch to Silent Alarm.
   c. By turning the silent test switch to Silent Trouble.
   d. By turning the unit test switch to TEST.

12. When the unit test switch is in the OFF position, which circuits are de-energized?

   a. Audible alarm.
   b. Supervisory alarm.
   c. Power supply.
   d. All of the system's circuits.

13. During normal conditions the status of the alarm relay is _____.

   a. Fully operated, contacts closed.
   b. Partially operated, contacts closed.
   c. Fully operated, contacts open.
   d. Partially operated, contacts open.

14. Usually a dial light indicator is controlled by the _____ contacts.

   a. Supervisory relay.
   b. Alarm relay.
   c. Alarm relay auxiliary.
   d. Supervisory relay auxiliary.

15. A ground at F7 of TB3 will cause:

a. An alarm condition on the number 7 alarm circuit.
b. Negative ground light to light.
c. Positive ground light to light.
d. Both ground lights to light.

16. Fill in the display status for the loss of power condition on the D eating Feed Tank Water Level Alarm System.

_____ pilot light.	_____ alarm target.
_____ supervisory target.	_____ unit test switch
_____ remote horn.	_____ white dial light.
_____ red dial light.	_____ blue dial light.

17. The lower section of the alarm switchboard is made up of the line panels. Each line panel consists of:

a. 10 two-line alarm units.
b. 5 alarm circuits.
c. 10 alarm circuits.
d. 1 two-line alarm unit.

18. Match the type of sensing switch with an alarm system using that type of switch. Items may be used more than once.

_____ Desuperheater.	a. Liquid level.
_____ Deareating feed.	b. Pressure.
_____ Lube oil low.	c. Water.
_____ Feed.	d. Temperature.

19. Alarm units mounted in a B-52 alarm panel control the following audio devices:

a. Remote horn and local bell.
b. Remote horn.
c. Trouble buzzer and remote horn.
d. Trouble buzzer.

20. When performing the silent alarm test on the number 1 alarm circuit, an alarm on the number 5 circuit will cause the alarm bell to sound.

a. True
b. False

21. On the answer sheet draw a simplified straight-line diagram of the trouble buzzer circuit of the Desuperheater High Temperature Alarm System. Label all of the major components. Do not label terminal board posts. Use standard symbols; for example, "Z" in a box is a buzzer. Identify the source and type of power. Use a schematic diagram.

22. Placing the line unit cutout switch in the test position will test the operation of the alarm initiating device.

a. True
b. False

23. A 100-line alarm switchboard would consist of _____ line panels.

a. 5
b. 10
c. 20
d. 50

24. Across what terminals of a B-51 alarm panel would an external alarm be connected?

a. EC and T.
b. EC and A.
c. ECC and A.
d. EC and ECC.

25. What indications will be observed on the alarm switchboard if the primary winding of TR opens?

a. All lines display yellow supervisory targets and no audible displays.

b. All lines display yellow supervisory targets and red alarm targets, and alarm bell will energize.

c. All lines display yellow supervisory targets, trouble buzzer energizes, and pilot light de-energizes.

d. All lines display yellow supervisory targets and red alarm targets, and alarm bell and trouble buzzer both energize.

26. The supervisory resistor acts as a:

a. Voltage divider.
b. Current limiter.
c. Filter component.
d. Dummy load.

27. In the trouble condition, what is the status of the two alarm unit relays?

	Supervisory	Alarm
a.	Restored	Restored
b.	Restored	Operated
c.	Operated	Restored
d.	Operated	Operated

28. Which operational test operates the extension relay?

a. Silent alarm test.
b. Alarm test.
c. Silent trouble test.
d. Trouble test.

29. The function of the B-52 alarm panel is to:

a. Provide power to the AC and DC circuits of the alarm system.
b. Monitor current flow in the sensing circuit.
c. Provide test circuits for the alarm systems.
d. House two supervised alarm systems.

30. If two alarm systems are controlled by a single sensing switch, the systems are:

a. Dependent.
b. Slaved.
c. Cross-coupled.
d. Resonant.